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Semi Annual Progress Report

NASA Grant NSG 1096

Research and Investigation of the Radiation
Induced by a Laser Beam Incident
on Sea Water

For the period September 1, 1974 - March 1, 1975

Principal Investigator: Fred W. Paul,
Research Scientist: A.V. Zimmerman III

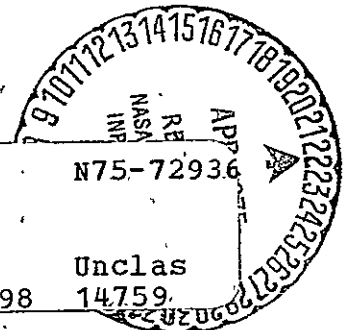
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OF THE RADIATION INDUCED BY A LASER BEAM
INCIDENT ON SEA WATER Semiannual Progress
Report, 1 Sep. 1974 - 1 Mar. 1975
(Chesapeake Coll.) 6 p

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September and October were spent assembling and troubleshooting the telescope, filter box, and monochromator assemblies. The filter box was revised and its temperature characteristics have been determined. The laser was received from the manufacturer in November and was made fully operational by December 6. Spectra of the bending mode of the water molecules and of the sulfate ions at concentrations similar to sea water were obtained.

Calibration of the filter system was begun. First, the peak bandpasses of the filters (all mounted in the filter box) were set at the proper wavelengths. This was done by bringing the filters up to the design temperature of 45°C and then tilting them while monitoring the bandpass with a $\frac{1}{2}$ m McPherson monochromator. A tungsten standard lamp was used as a source. To check repeatability, the filter box and filters were cooled and reheated and the peak transmission remeasured many times. No change in peak transmission was seen.

Next, the total relative transmissions of the filters were determined. This took into account not only differences in bandpass transmission but also differences in wing rejection. The measurements were relative because absolute transmissions were not needed and would be very difficult to determine accurately. A standard lamp at a known temperature was used to illuminate each filter in turn while the total integrated transmission of each filter was measured directly with a phototube. The resulting intensities were treated (after blackbody corrections) as if the

filters had been looking at a continuum with a flat spectral distribution. A transmission correction factor or proportionality constant was then determined for each filter. Tests were repeatedly made to be sure the correction factors did not change and no change was seen.

The capability of the filter system to reject backscattered laser light was also measured for each filter. This was done by placing a diffusing target in the beam, collecting the backscatter with the telescope system, and directing it into the filter box. It was found that most targets such as paper and anodized aluminum fluoresced when exposed to the intense laser beam.

This fluorescence, visible with laser goggles, could also be detected with the filter system. Burnished stainless steel did not seem to fluoresce when viewed with laser goggles and the signal measured with this target was low enough.

During the latter part of January, the test tank was filled with Langley tap water and K_2SO_4 added to make the SO_4 concentration comparable to a sea water salinity of 34%. Before tests could begin, the laser broke down again. A factory repairman came to Langley, replaced the ruined components, and by the last of January testing was finally started. The filter system could easily see the sulfate and water Raman signals riding on top of a fluorescence background that was about 3 to 4 times more intense than the Raman.

The first part of February was spent in measuring the repeatability of the SO_4-H_2O ratio and how it was effected by changes

in instrumental parameters. Results showed that the ratio could be determined to about $\pm 15\%$ and that a filter scan having this reliability could be made in about 30 seconds. Cutting the sulfate concentration in the tank by a half reduced the $\text{SO}_4\text{-H}_2\text{O}$ ratio by about a half which indicated that SO_4 and H_2O were being measured rather than some instrumental effect.

While experiments were being conducted with the filter box, the laser began to lose power again. The filter system could still be used but the power loss was so great that the monochromator did not have enough input to isolate the SO_4 Raman band. (It was also discovered at this time that the gratings had somehow lost 40-50% of their efficiency.)

Before sending the laser back for repairs, a field trip was made to the Coast Guard pier at Yorktown, Virginia on February 18-21. The purpose of the experiment was to see how the fluorescence background of natural water would effect the sulfate measurement with the filter system. Because of long wavelength water fluorescence no sulfate or water Raman signal could be detected. The signal received was almost identical to that seen with a standard lamp, in other words, a continuum. The monochromator was used to make scans of the fluorescence and large water peak (OH stretch). These scans showed a broad fluorescence centered at about 5800Å that had an intensity comparable to the large water peak.

Samples were collected the first week in March from both the York River and the Hampton Roads and studied in the laboratory. Scans of these samples showed the same intense fluorescence in the

region of the sulfate and water Raman bands.

The laser was sent back for repairs and the monochromator was sent in for new mirrors and gratings.

The literature was searched for some indication of the cause and the peculiar shape of the fluorescence. It was found that a pigment found in red algae could have been responsible, however, a sample taken from the test tank filled with Hampton Roads water revealed only a few green algae and no trace of reds. The solution of the puzzle about this fluorescence now awaits additional experimentation which will be done when the apparatus has been repaired.

Future Plans

As soon as the laser and monochromator return, work on the fluorescence problem will be renewed. Its cause, whether due to particulate (algae) or dissolved material, will be investigated. The late spring and summer will be spent on field trips and on collecting water samples from as many areas as possible.

The U.V. excited fluorescence of water will be studied this summer or next fiscal year. These studies may yield information on in situ formation of fluorescing material and on how residence times affect its concentration. The laser technique used to measure the fluorescence can easily be adapted to a remote sensing system using interference filters. Much of the equipment needed for such a system is already available. The blue fluorescence

of water is a subject on which further research may yield another approach to assessing water quality.

During this period, two unusually talented students at Chesapeake College were instructed in this program. Their efforts revealed the following two items of information:

1. The Chesapeake Bay Institute of The Johns Hopkins University has compiled the most detailed bibliography about water conditions in the Chesapeake Bay that we have found. In particular, numerous charts and tables of data about the lateral and vertical distribution of temperature and salinity are cited. Details have been transmitted to the Technical Monitor.
2. Cooperative effort with the Chesapeake Bay model at Matapeake, Maryland, will not be possible because unanticipated construction delays have set back the expected completion date to 1977.